Spacelab J

- Microgravity Sciences
- Life Sciences

Why Study Materials Science In Microgravity?

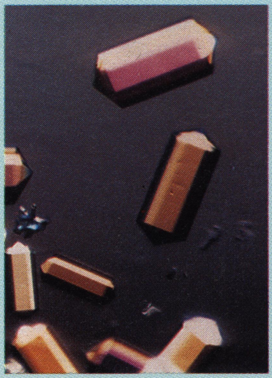
Dust settles gently onto a desktop, highlighted by a sunbeam through a window; a long fly ball arcs into centerfield where a player races to meet it; a glass-blower at a county fair spins molten glass to keep it from sagging as it is shaped; and a small child looks in wonder at the rain bouncing and splashing on the surface of a lake. Gravity is such an accepted part of our lives that we rarely think about it, even though it affects everything we do. It causes things to settle to the ground and provides an up-and-down frame of reference for our everyday lives.

The effects caused by gravity are not always desirable, however. This is especially true for certain phases of materials processing. Mixers must operate almost constantly to keep ingredients uniformly blended; molten items produced by some methods must be cooled quickly, or spun like the molten glass at the county fair, to prevent distortion of their external shape; and some products that depend on a well-ordered internal arrangement, such as electronic components, are not as perfectly ordered as they could be because of gravity's effects.

Gravity also limits scientists' efforts to study the various processes used in manufacturing and the internal changes to the structure of the material as it reaches its final form. For example, gravity is the driving force behind convection currents between hot and cold regions. These currents mask other events that scientists wish to study and can lower the quality of the final product by causing it to be improperly mixed. Gravity also causes other phenomena that can mask subjects of interest to scientists.

In a spacecraft orbiting the Earth, gravity is greatly reduced. In this environment, known as microgravity, scientists can strip away the masking effects of gravity and pursue research not possible on Earth. Conducting materials science research in microgravity may eventually lead to improvements in both production methods and final products.

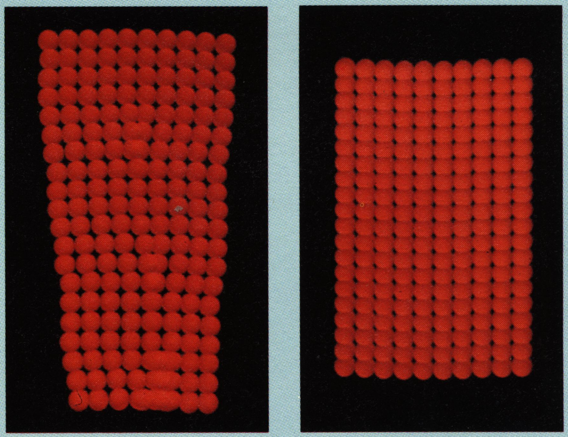
There will be 27 microgravity sciences experiments conducted on Spacelab J, exploring the areas of electronic materials, metals and alloys, glasses and ceramics, fluid dynamics and transport phenomena, and biotechnology. The experiments will attempt to produce new products, evaluate new or improved production methods, and examine the suitability of microgravity for certain manufacturing processes. One technology experiment will support the others by gathering data on the acceleration environment of the Spacelab module. Examples of Spacelab J investigations include the following:



Larger, more perfect protein crystals, such as these lysozyme crystals, can be grown in microgravity.

Protein Crystal Growth

Proteins play an important role in everyday life, from providing nourishment to fighting disease. Analyses of the crystal forms of proteins can reveal much about how they work. Earth-grown crystals that are large enough to study often have numerous flaws caused by gravity. The study of crystals grown in microgravity could lead to the development of foods with higher protein content and to the design of more effective drugs. The Spacelab J experiment will grow 10 to 15 different types of protein crystals.



Gravity-induced flows can cause defects inside many materials, especially those with crystalline or lattice structures. These defects can cause structural weakness or prevent electricity from being transmitted efficiently. They also limit what can be learned about the structure and function of various crystals. Processing in microgravity can result in nearly perfect internal structure.

Just like the oil and colored vinegar pictured, some metals will not mix. Scientists expected that an even mixture could be obtained in space. However, previous experiments did not show this result.

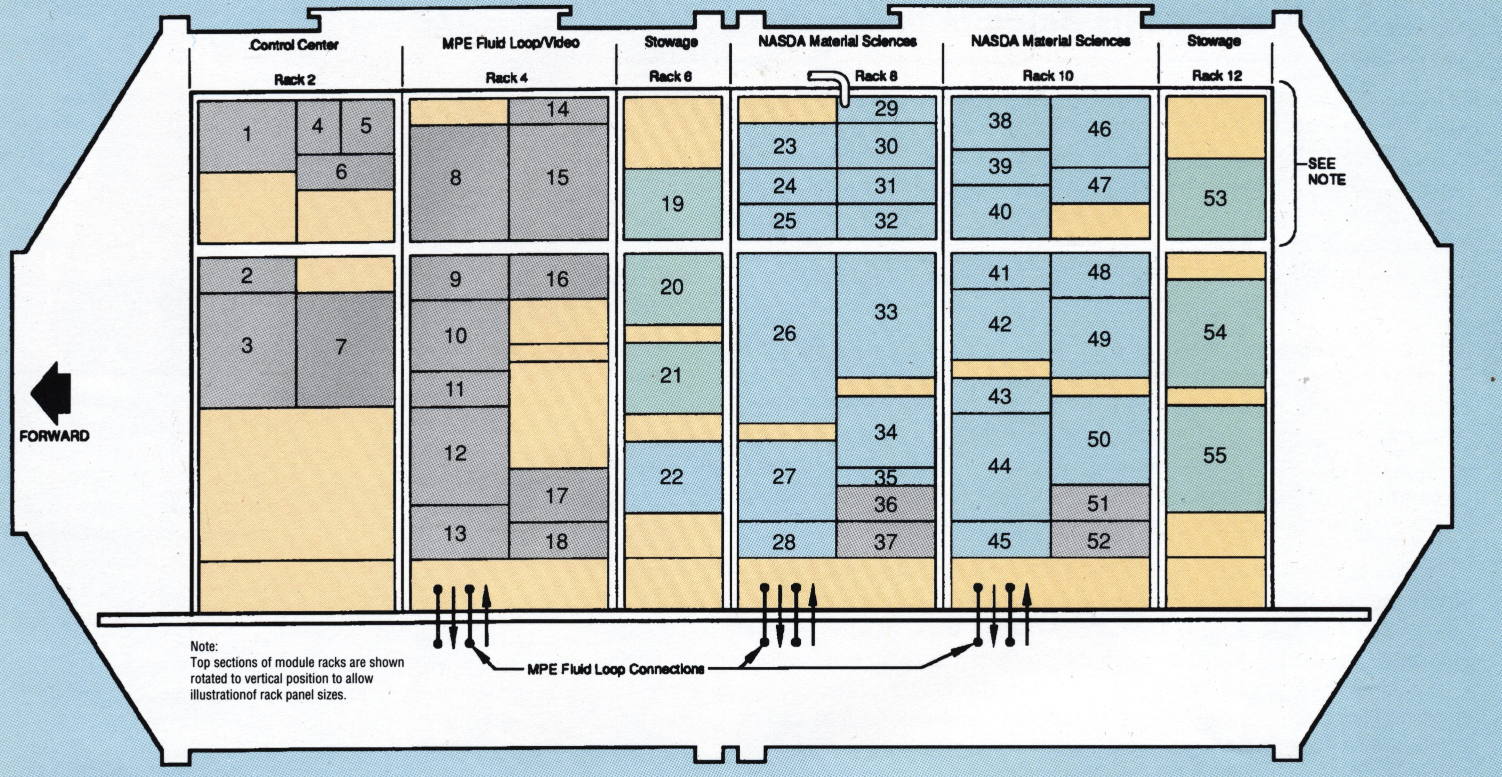
Solidification Of Immiscible Alloys

Scientists are interested in a number of alloys that cannot be produced on Earth because the ingredients, like oil and water, are immiscible. Previous experiments in microgravity did not result in uniform mixtures as expected and scientists have developed a theory to explain the results. The Spacelab J experiment is being conducted to help confirm the theory.

To study bubble behavior and interaction, a large bubble is injected into the chamber and the chamber is shaken to produce a large number of smaller bubbles.

Bubble Behavior

In the absence of gravity, do bubbles still rise to the top of a fluid? While experiments have been performed to answer this and other basic questions about bubble behavior in microgravity, many areas still await examination. One Spacelab J experiment will examine bubble behavior under a variety of conditions and examine how the bubbles interact with one another. These data will benefit both materials processing and basic scientific knowledge.

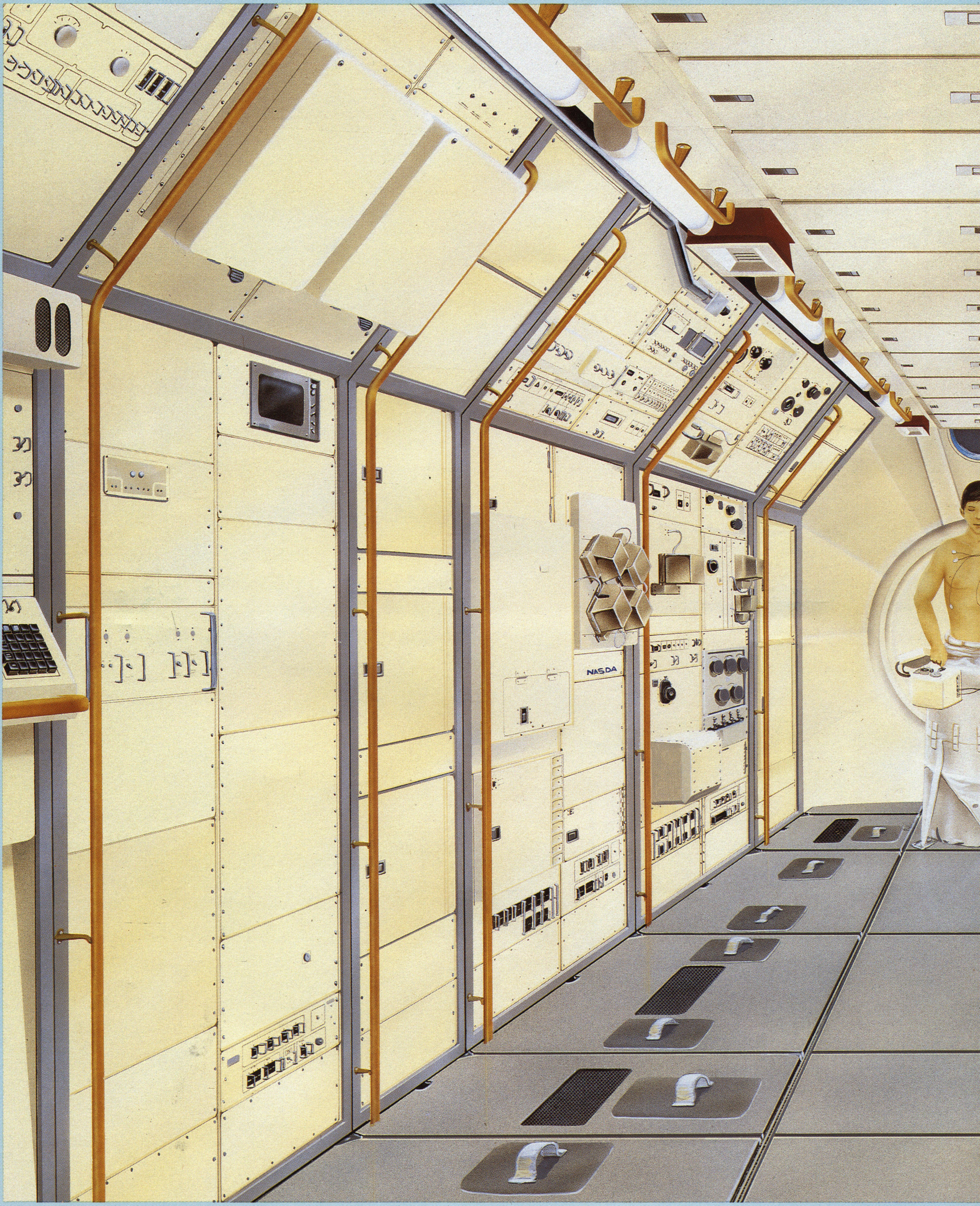


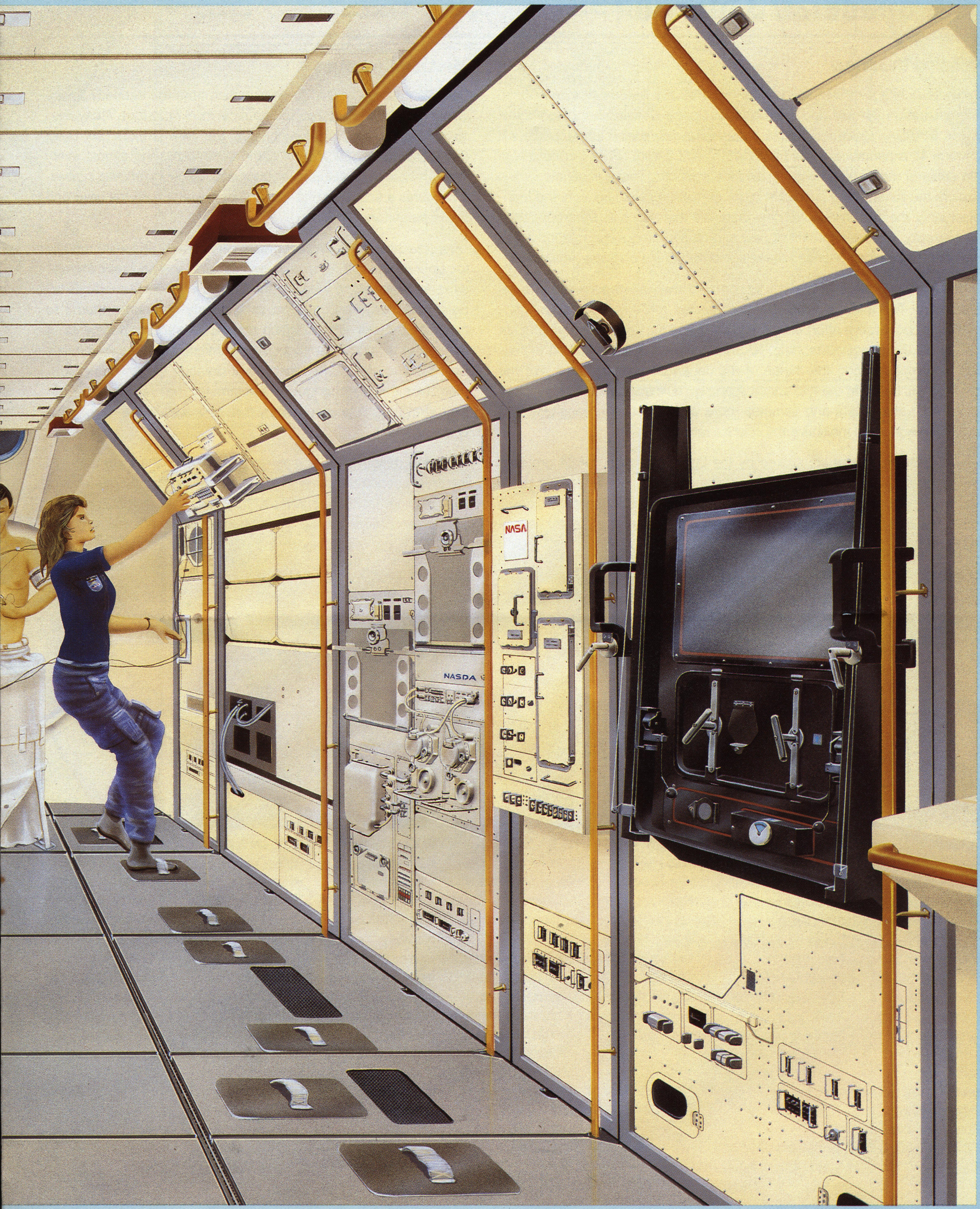
Starboard Side

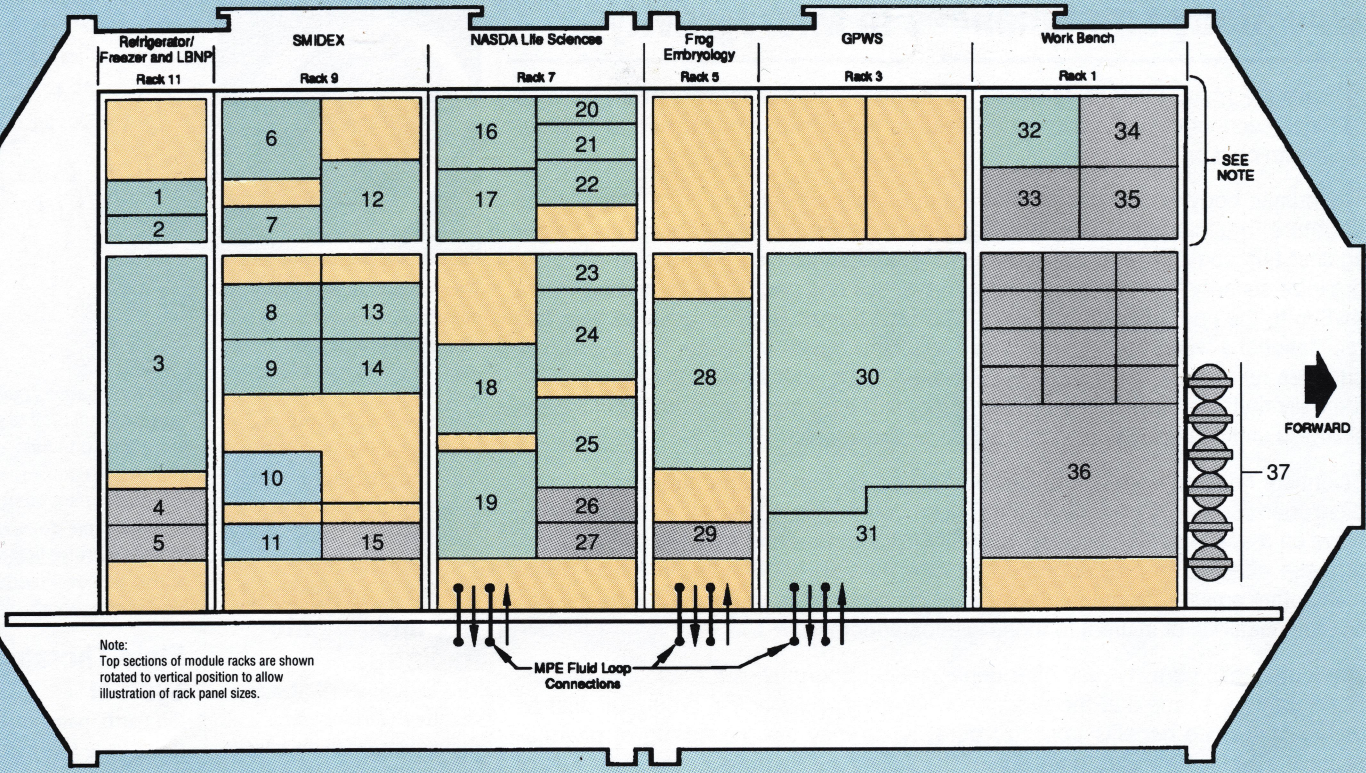
Grey = Mission Support Hardware
Blue = Microgravity Science Related Hardware
Yellow = Blank Closure Panels
Green= Life Sciences Related Hardware

1. Environmental Control System Monitor
2. Intercom Master Control
3. High Data Rate Recorder
4. Caution and Warning/Fire Suppression System Control Panel
5. Pyro Control Access
6. Electrical Power Distribution System Monitor and Control
7. Data Display System
8. Video Cassette Recorder
9. Video Analog Switch Controls
10. Intercom Remote Station
11. Fluid Loop Monitor and Control Panel
12. Mission Peculiar Equipment Pump System
13. Experiment Heat Exchanger
14. Video System Power Switches
15. Video Cassette Recorder
16. Television Monitor
17. Remote Access Unit Access Panel
18. Experiment Power Switching Panel
19. Frog Embryology Experiment Rack Stowage Container
20. Frog Embryology Experiment Rack Stowage Container
21. Frog Embryology Experiment Rack Stowage Container
22. Rack Stowage Container
23. Sample Stowage Container
24. Image Furnace Drive Controls
25. Image Furnace Control
26. Image Furnace
27. Sample Stowage Container
28. Power Distribution Box #1
29. Vacuum Vent (Blue)
30. Data Recording Video Tape Recorder
31. Central Interface and Control Equipment
32. Continuous Heating Furnace Controls
33. Continuous Heating Furnace
34. Vacuum Pump Package Equipment
35. Pilot Valve Unit
36. Experiment Power Switching Panel Access
37. Experiment Power Switching Panel
38. Organic Crystal Growth Facility
39. Large Isothermal Furnace Controls
40. Large Isothermal Furnace
41. Gradient Heating Furnace Controls
42. Gradient Heating Furnace
43. Acoustic Levitation Furnace Controls
44. Acoustic Levitation Furnace
45. Power Distribution Box #2
46. Liquid Drop Experiment Facility
47. Specific Experiment Control Equipment
48. Fluid Physics Experiment
49. Crystal Growth Experiment Facility/Gas Vapor Experiment Facility
50. Compressed Gas Supply Equipment
51. Experiment Power Switching Panel Access
52. Experiment Power Switching Panel
53. Lower Body Negative Pressure Experiment Rack Stowage Container
54. Fluid Therapy System Rack Stowage Container
55. Lower Body Negative Pressure Experiment Rack Stowage Container

NOTE: Blank closure panels cover equipment for safety and to provide proper airflow for operations.


NASDA


NASA
NASDA



Port Side

Grey = Mission Support Hardware
Blue = Microgravity Sciences Related Hardware
Yellow = Blank Closure Panels
Green= Life Sciences Related Hardware

1. Lower Body Negative Pressure Experiment/Life Sciences Laboratory Equipment Microcomputer
2. Lower Body Negative Pressure Experiment Rack Interface Panel
3. Life Sciences Laboratory Equipment Refrigerator/Freezer
4. Experiment Power Switching Panel Access
5. Experiment Power Switching Panel
6. Lower Body Negative Pressure Experiment Rack Stowage Container
7. Automatic Blood Pressure Monitoring System
8. American Flight Echocardiograph
9. Payload Stowage
10. Space Acceleration Measurement System
11. Space Acceleration Measurement System Connector Bracket Panel
12. Fluid Therapy System Rack Stowage Container
13. Fluid Therapy System Stowage
14. Payload Stowage
15. Experiment Power Switching Panel
16. Life Sciences Stowage
17. Life Sciences Stowage
18. Low-Temperature Thermoelectric Incubator
19. Free Flow Electrophoresis Unit
20. Physiological Data (Telemetry) Interface Rack
21. Light Impulse Controller
22. Data Interface Unit
23. Power Distribution Box
24. High-Temperature Thermoelectric Incubator
25. Vestibular Function Experiment Unit
26. Experiment Power Switching Panel Access
27. Experiment Power Switching Panel
28. Frog Environmental Unit
29. Experiment Power Switching Panel
30. General Purpose Work Station System
31. General Purpose Work Station Lower Electronics Box
32. Payload Stowage Container
33. Tool and Maintenance Equipment Stowage
34. Standard Spacelab Stowage Container
35. Standard Spacelab Stowage Container
36. Spacelab Workbench
37. Spare Lithium Hydroxide Canisters

NOTE: Blank closure panels cover equipment for safety and to provide proper airflow for operations.

Why Study Life Sciences In Microgravity?

There are many reasons to study life sciences in microgravity, from obvious ones such as ensuring astronaut health to less obvious ones such as improving health care on Earth.

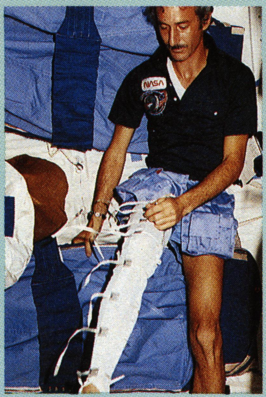
The human body is designed to operate in Earth's gravity field (1-g). Our skeletal structure, muscles, tendons, and ligaments developed to support our weight against this constant pull. Other systems regulate the even distribution of fluids, organize sensory input to provide us with balance and coordination, and provide a rhythm to the operations of the body. When the human body is removed from this gravitational environment, as it is when a person travels in space, many complex changes take place: bones become weaker, fluids shift toward the upper body, the daily rhythms of the body are disrupted, and a person may suffer from motion sickness until the body adapts to the new environment.

Scientists need to understand these changes so that countermeasures can be developed for long-term spaceflight. These countermeasures will help make long stays on a space station or a trip to another planet feasible. Also, studies of some of these effects can provide important new medical information that may affect many other areas — from the care of persons exposed to prolonged bedrest (such as the critically ill or injured) to those with osteoporosis.

In addition, microgravity may offer unparalleled opportunities for research on particular body systems and the production of advanced medical products. Just as materials science benefits from microgravity, so may the processing of pharmaceutical agents. New and more potent medicines are just one possible benefit of such research and processing.

Life sciences research allows us to begin planning for truly long-term stays in space by answering such questions as "Can life be conceived and develop normally in the absence of gravity?" and "What are the effects of cosmic radiation, and how can we best minimize such exposure?"

There will be 17 life sciences investigations conducted on Spacelab J, exploring the areas of cell and developmental biology, human physiology, and radiation and environmental health. One technical experiment will examine the production of medicines and the administration of medical fluids as part of the preparations for Space Station Freedom. *Some examples of Spacelab J life sciences investigations include the following:*



Muscle size in the legs changes with exposure to microgravity. A stocking plethysmograph, a device for measuring the volume of a limb, will be used on Spacelab J to help determine these changes. Several times over the course of the mission, an astronaut will put on the plethysmograph — similar to the one pictured — pull the tapes tight and mark them. By comparing the marks, changes in muscle volume can be measured.

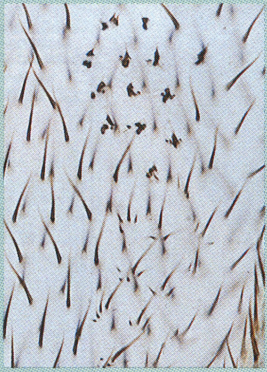
Magnetic Resonance Imaging (MRI)

This experiment does not actually take place in space but on the ground before and after the mission. Unlike X-rays, which use harmful (ionizing) radiation, MRI uses low-frequency radio waves to probe the body. MRI scans allow researchers to distinguish between fat, muscle, blood, cartilage, bone, and other tissues. By doing pre- and postmission scans, researchers can determine changes not only in the size but also in the chemical composition of the body parts being scanned. The Spacelab J data can then be compared with those of bedrest subjects to determine the changes brought about by the microgravity environment.

This transverse MRI image details all the different structures in a portion of the thigh of a bedrest subject.

Genetic Effects of HZE and Cosmic Radiation

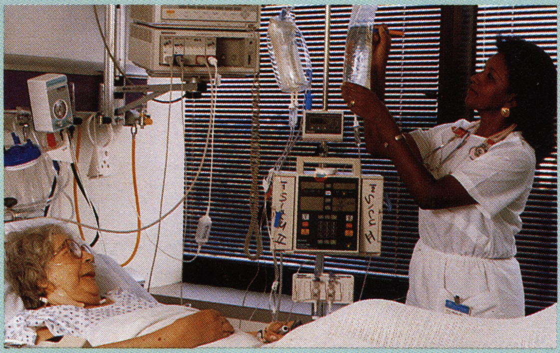
This experiment will study fruit flies (*Drosophila melanogaster*) to investigate the possible effects of high-charge and high-energy galactic rays (HZE) and other cosmic radiation on living organisms. Of particular interest are the genetic effects. This species of fruit fly is used because mutation-inducing radiation causes cells on the fly's wing to produce several hairs, instead of the usual one hair. This mutation, therefore, is easy to spot and can provide scientists with information on radiation levels and effects. This information is useful for planning long-term missions, especially those at the altitude of Space Station *Freedom*, where radiation levels are higher.



Radiation causes cells on the wings of fruit flies to produce more than one hair. Information developed from this experiment can be used by the people developing radiation protection for Space Station* Freedom *and similar spacecraft.

Fluid Therapy System

On Earth, patients needing fluids have a bag or bottle of the appropriate fluid hung above them and a drip initiated into a vein, a process known as intravenous (IV) fluid therapy. Gravity provides the force necessary for this process. But how can an astronaut get an IV in space? The answer is the Fluid Therapy System, being developed for Space Station *Freedom*. This system is designed to produce sterile water, formulate the appropriate solutions, and pump them into the patient. It will be tested under microgravity conditions on Spacelab J, so any changes needed in either the hardware or operating procedures can be made and tested again before installation on *Freedom*.



On Earth, gravity powers IV fluid therapy, but special equipment is needed in microgravity. The Fluid Therapy System, developed for use on Space Station* Freedom*, will be tested on Spacelab J.

The Spacelab J Mission

Mission Overview

Spacelab J is a joint venture between the National Aeronautics and Space Administration (NASA) and the National Space Development Agency of Japan (NASDA). Crewmembers in a pressurized Spacelab long module will perform 43 experiments — 34 from NASDA and 9 from NASA — primarily in the areas of materials processing and life sciences. These experiments will explore the suitability of microgravity for certain types of research and manufacturing, the possibilities for new materials that can only be produced in microgravity, the development of new and refined production methods, and the effects of microgravity and the space environment on living organisms.

NASDA began developing its portion, known as the First Material Processing Test (FMPT), in 1979 and contacted NASA in 1984 about conducting a cooperative effort on the Shuttle. Since the Japanese experiments did not fill the Spacelab module, NASA developed and manifested experiments complementing the theme of the Japanese investigations. Further negotiations between the two space agencies, culminating in 1991, resulted in plans to share data and samples more widely between Japanese and U.S. investigators to maximize the science return.

Mission responsibilities are shared by the U.S. and Japan. NASA provides payload integration, launch services, mission management, and some post-flight support. NASDA is responsible for selecting the Japanese experiments, overseeing their development, and ensuring that all equipment is ready for flight.

Mission Operations

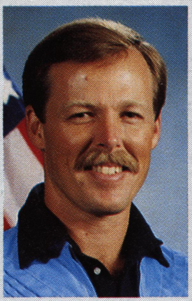
Spacelab J is scheduled to be launched from the Kennedy Space Center to a 296-kilometer (160-nautical mile) orbit for a 7-day mission. The mission plan is ambitious: the crew is extremely busy, many experiments share the same equipment, and almost every kilowatt-hour of available energy is used. Careful planning, however, ensures a schedule that meets the needs of both the crew and the investigators.

Upon reaching orbit, crewmembers prepare the Spacelab module for operations and retrieve materials from the middeck storage lockers for use in the module. The Shuttle is positioned with its tail pointed toward Earth (known as a gravity-gradient attitude) to minimize thruster firings, which disturb sensitive experiments. A number of experiments, especially in the life sciences, begin less than 7 hours after launch to prevent damage to perishable samples, to measure changes in specimens that rapidly adapt to microgravity, and to ensure maximum exposure to the microgravity environment.

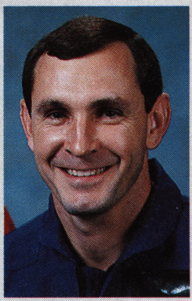
Spacelab deactivation begins near the end of the sixth day and the crew spends the seventh preparing for landing. Some 3 hours after landing, technicians remove the items stored in the middeck refrigerator/freezer, while the animal experiments are removed within 24 hours of landing.

Crew

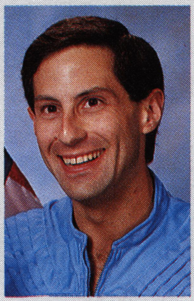
Seven crewmembers comprise the crew for the Spacelab J mission. Working in two shifts, they are an integral part of the research, both controlling experiments and participating as experimental subjects.



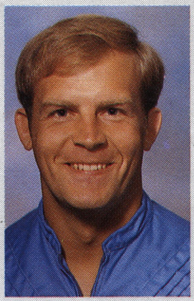
Captain Robert L. "Hoot" Gibson is the Spacelab J Mission Commander. He earned his bachelor of science degree from the California Polytechnic State University in 1969, is a certified test pilot, is a graduate of the Naval Fighter Weapons School ("Topgun"), and has received numerous awards including the Distinguished Flying Cross. He has flown on STS-41B, STS-61C, and STS-27.



Major Curtis L. Brown, Jr., is the Spacelab J Pilot. He earned a bachelor of science degree in electrical engineering from the U.S. Air Force Academy in 1978, attended the Air Force Fighter Weapons School in 1983, and graduated from the Air Force Test Pilot School in 1986. Spacelab J will be his first spaceflight.



Dr. Jay Apt is the Spacelab J Flight Engineer. He earned a bachelor of arts degree in physics from Harvard University in 1971, and his doctorate in physics from the Massachusetts Institute of Technology in 1976. He has previously flown on STS-37.



Lt. Col. Mark C. Lee is the Payload Commander for Spacelab J. He earned his bachelor of science degree in Civil Engineering from the U.S. Air Force Academy in 1974 and his master of science degree in Mechanical Engineering from the Massachusetts Institute of Technology in 1980. He has previously flown on STS-30.

Dr. Mae C. Jemison, M.D., is the Spacelab J Science Mission Specialist. Before joining NASA in 1987, she worked in both engineering and medical research. She earned a bachelor of science degree in Chemical Engineering from Stanford University in 1977 and her doctor of medicine degree from Cornell University in 1981.

Dr. N. Jan Davis is the Mission Specialist assigned to Spacelab J. She earned her bachelor of science degree in Applied Biology from the Georgia Institute of Technology in 1975, a bachelor of science degree in Mechanical Engineering from Auburn University in 1977, and her master of science and doctorate degrees in Mechanical Engineering from the University of Alabama in Huntsville in 1983 and 1985, respectively.

Dr. Mamoru Mohri is the first NASDA astronaut and is the Japanese Payload Specialist for the mission. He received his doctorate from Flinders University, Australia, in 1976. His major fields of study were surface physics and ultra-high vacuum science.

NASA
National Aeronautics and Space Administration

NASA Fact Sheet

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

September 1992

USMP-1: United States Microgravity Payload 1

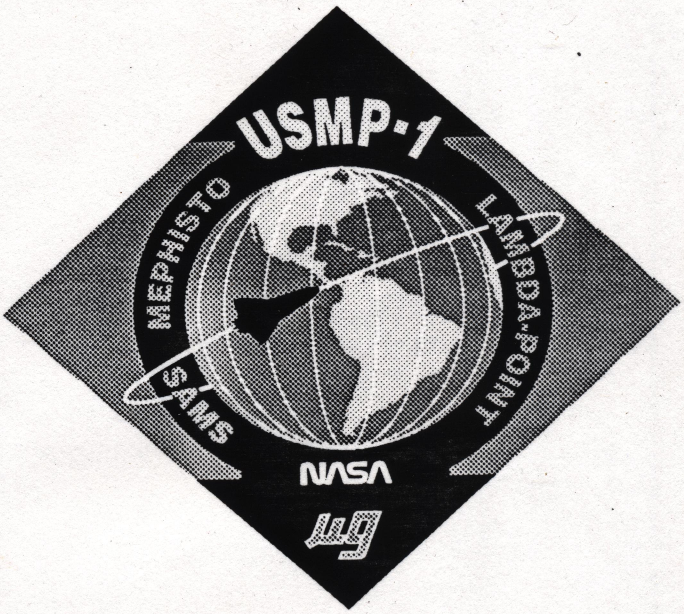
In October 1992, the first United States Microgravity Payload (USMP-1) will be launched aboard Space Shuttle Columbia for a 10-day mission. The USMP program is a series of NASA missions designed for microgravity experiments that do not require the "hands-on" environment of the Spacelab.

The Marshall Space Flight Center in Huntsville, Ala. manages USMP for the Office of Space Science and Applications at NASA Headquarters.

The USMP-1 payload will carry three investigations. The Lambda-Point Experiment (LPE) will study fluid behavior in microgravity. The Materials for the Study of Interesting Phenomena of Solidification on Earth and in Orbit (Matériel pour l'Etude des Phenoménes Intéressant la Solidification sur Terre et en Orbite, or MEPHISTO) will study metallurgical processes in microgravity. The Space Acceleration Measurement System (SAMS) will study the microgravity environment onboard the Space Shuttle.

In orbit, the USMP crew will activate the carrier and the experiments, which will operate for about six days during the mission. Science teams at MSFC's Spacelab Mission Operations Control facility will command and monitor instruments and analyze data.

Two Mission-Peculiar Equipment Support Structures (MPESS) in the Shuttle cargo bay are used for USMP-1. Carrier subsystems mounted on the front MPESS provide electrical power, communications, data-handling capabilities, and thermal control. The USMP carrier was developed by MSFC.



Lambda-Point Experiment

Principal Investigator: Dr. J.A. Lipa
Stanford University, Stanford, Calif.
Project Manager: R.M. Ruiz
Jet Propulsion Laboratory, Pasadena, Calif.

The Lambda-Point Experiment will study liquid helium as it changes from normal fluid to a superfluid state. In the superfluid state, helium

(Continued on next page)

moves freely through small pores that block other liquids, and it also conducts heat 1,000 times more effectively than copper. This change occurs at liquid helium's "lambda point" (-456 degrees Fahrenheit or 2.17 degrees Kelvin). Because the transition from one phase to another causes the interaction of large numbers of particles, it is of great scientific interest.

The transition from fluid to superfluid state can be studied more closely in microgravity than on Earth. Gravity causes a sample of liquid helium to have greater pressure at the bottom than at the top, in turn causing the top of the sample to become superfluid at higher temperatures.

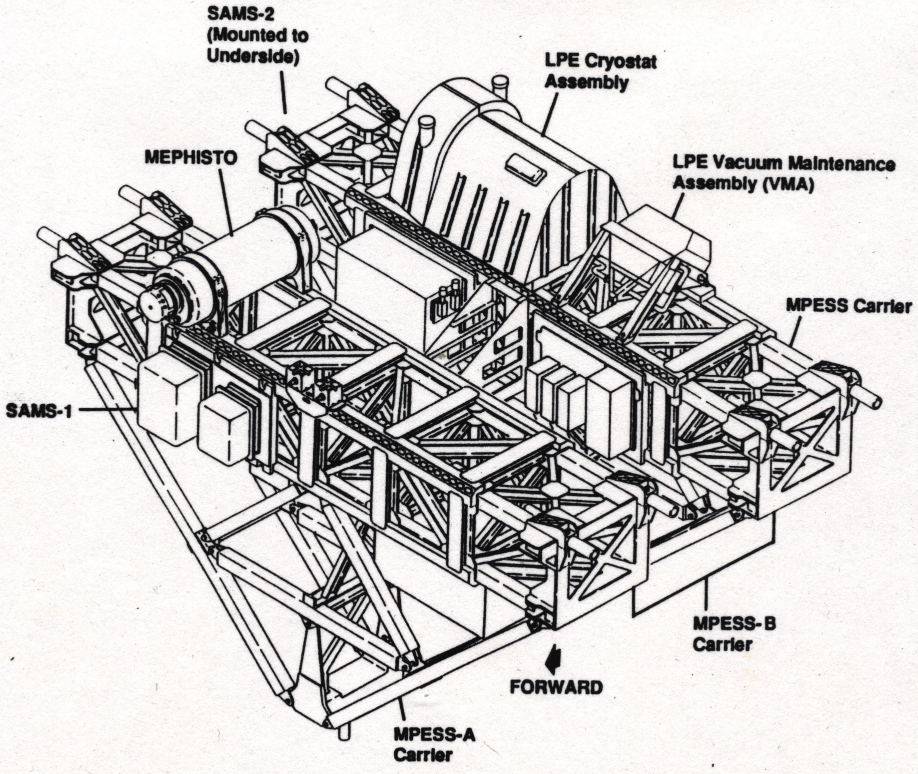
Onboard USMP, a sample of helium cooled far below the lambda point will be placed inside a low temperature cryostat (an apparatus used to keep something cold, such as a thermos bottle). During a series of two-hour runs, the temperature of the helium will be raised through the transition point by a precision temperature-control system. Sensitive instruments inside the cryostat will measure the heat capacity of the liquid helium as it changes phases. The temperature of the helium sample will be maintained to within a billionth of a degree during the experiment.

MEPHISTO

Principal Investigator: Dr. J. J. Favier
Commissariat á l' Energie Atomique
Grenoble, France
Project Manager: G. Cambon
Centre National d'Etudes Spatiales
Toulous, France

MEPHISTO (Materials for the Study of Interesting Phenomena of Solidification on Earth and in Orbit) will study the behavior of metals and semi-conductors as they solidify. The experiments will help determine the effect gravity has during solidification at the point where solid meets liquid, called the solid/liquid interface. Data gathered from MEPHISTO will be used to improve molten materials. For example, more resilient metallic alloys and composite materials could be designed for engines that will power future aircraft and spacecraft.

The cylindrical-shaped MEPHISTO furnace experiment onboard USMP-1 will contain three identical rod-shaped samples of tin-bismuth alloy. MEPHISTO will process the samples using two furnaces, one fixed and one moving. As a run begins, the mobile furnace will move outward from



the fixed furnace, melting the samples. The mobile furnace then moves back towards the fixed furnace slowly, and the sample resolidifies. The fixed furnace contains a stationary solid/liquid interface to be used as a reference for studying the mobile solid/liquid interface.

During the experiment runs, a small electrical voltage will constantly measure the temperature changes at the interface to verify solidification rates. During the last experimental run, electrical pulses will be sent through one sample, thus "freezing" the shape of the interface for post-mission analysis.

The MEPHISTO apparatus allows many cycles of solidification and remelting and is particularly well-adapted for long-duration missions. During the mission, scientists will compare the electrical signal to data from a SAMS sensor to see if the Shuttle's movement is disturbing the interface. They then can make adjustments to the experiments if necessary. Post-mission analysis of the space-solidified sample will allow correlation between the electrical measurements and changes in the sample.

Space Acceleration Measurement System

Scientific Investigator: Mr. Charles Baugher
Marshall Space Flight Center, Huntsville, Ala.
Project Manager: R. De Lombard
Lewis Research Center, Cleveland, Ohio

The SAMS experiment measures and records the Shuttle's acceleration and vibrations, which could affect sensitive microgravity investigations. SAMS supports both the LPE and MEPHISTO investigations, and it also characterizes acceleration's effect on the USMP carrier. By measuring the residual accelerations (such as those caused by orbiter thruster firings), scientists can determine how they influence experiment results.

Two SAMS instrument systems with four remote triaxial sensor heads will fly on STS-52. Two sensor heads will be mounted on the LPE cryostat, and two will be placed near MEPHISTO. Each sensor has three single-axis acceleration sensors. Cables will connect the sensors to the SAMS electronics package. Each sensor produces signals in response to accelerations. Electronics amplify and filter the signals, then convert them into digital data.

Scientists on Earth receive the data and can adjust any experiments disturbed by the acceleration. Scientists are particularly interested in measurements made during specific Shuttle maneuvers and periods of intense crew activity. Some maneuvers will be done intentionally to calibrate the SAMS. Though SAMS has flown on previous Shuttle missions, this is the first time the investigation has studied the cargo bay, and the first time data will be relayed to Earth for up-to-the-minute adjustments of experiments.

Management Team

NASA Headquarters
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Mission Scientist:
Dr. S.L. Lehoczky
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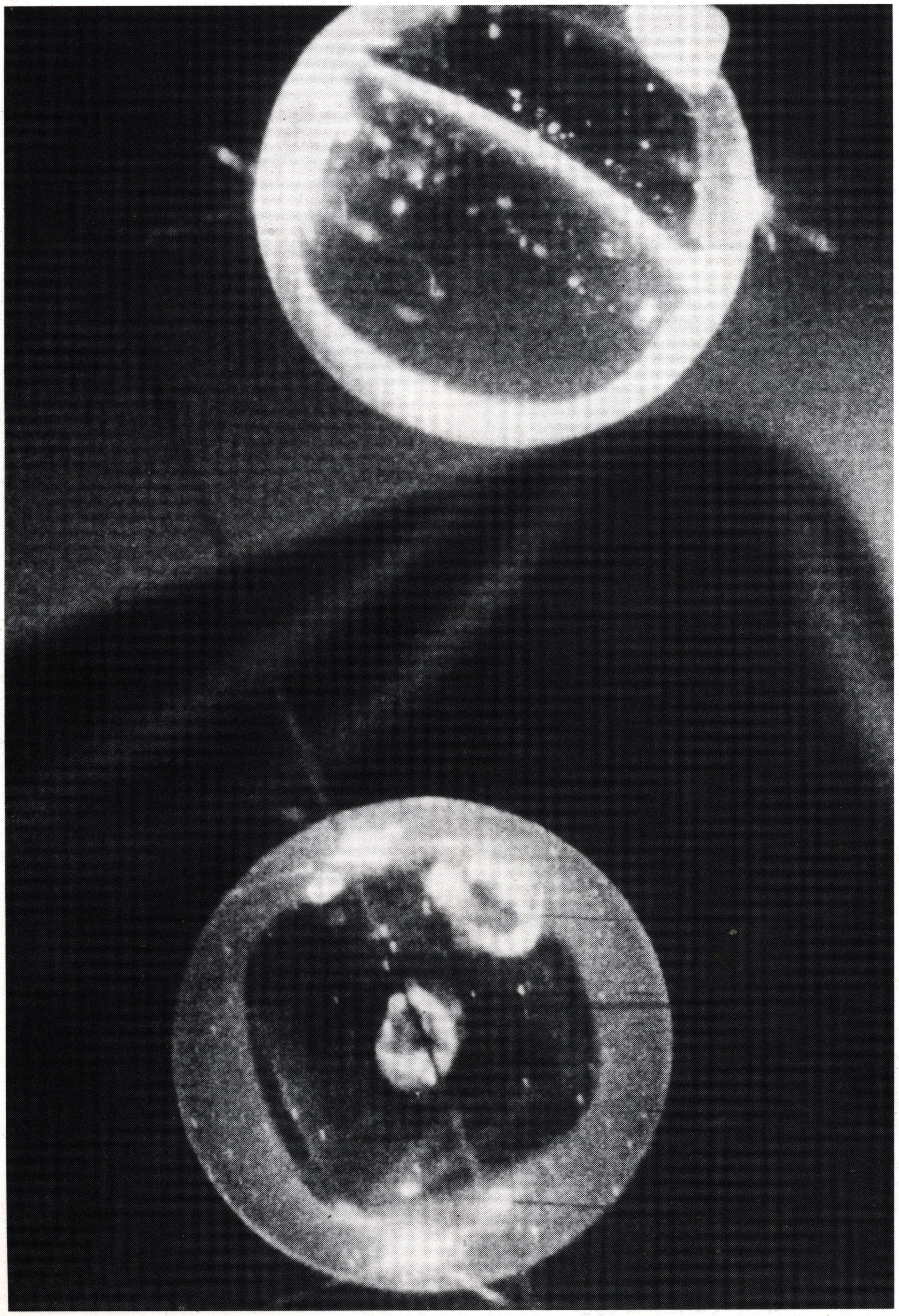
Chief Engineer:
W.L. Peters
Science and Engineering

NASA—MSFC

The Drop Physics Module

EXPERIMENTS IN MICROGRAVITY



THE DROP PHYSICS MODULE WILL INVESTIGATE THE DYNAMICS OF FREE-FLOATING LIQUID DROPS IN A MICROGRAVITY ENVIRONMENT.

NASA MICROGRAVITY

NASA
National Aeronautics and Space Administration

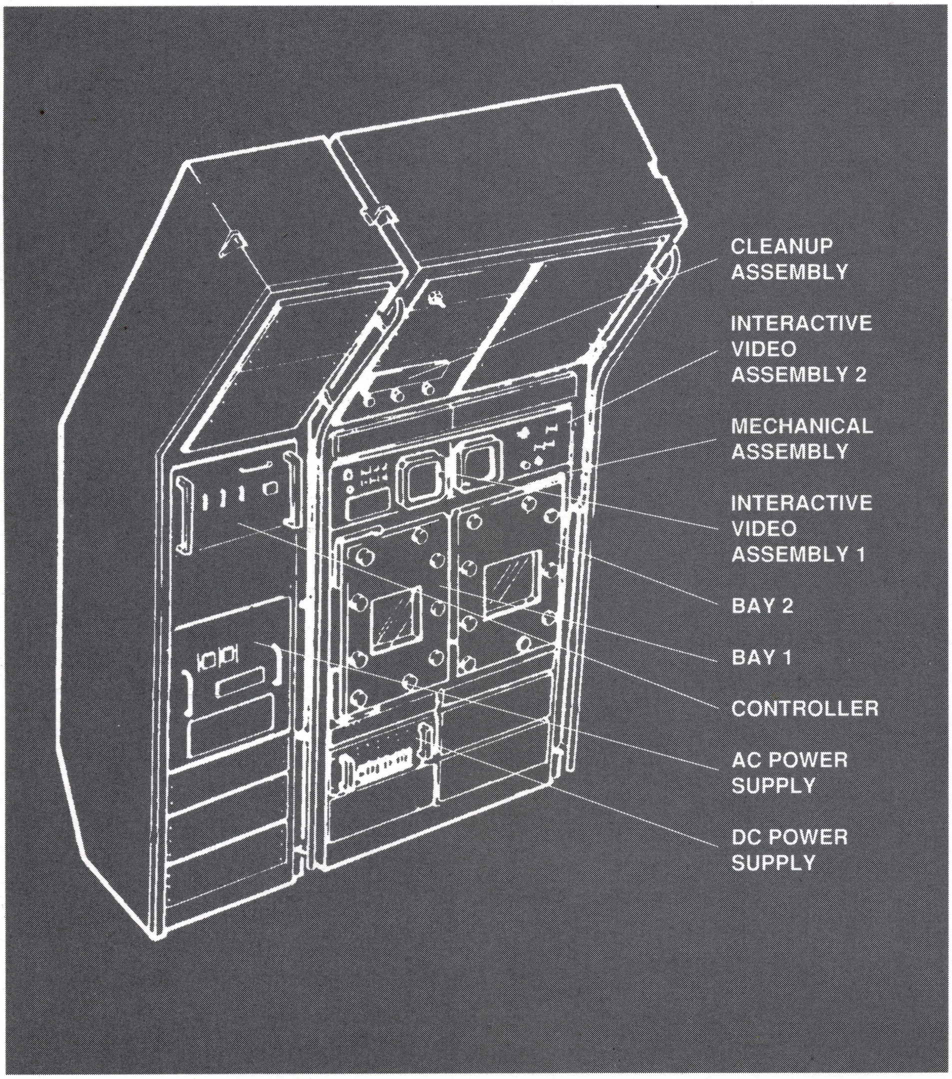
Introduction

The Drop Physics Module (DPM) will support a series of fluid dynamics experiments performed in the nearly gravity-free conditions of space. The experiments are designed to investigate the surface properties of various uncontained liquid drops, to study the surface and internal features of drops that are being vibrated and rotated and to test a new technique for measuring surface tensions between two immiscible (unmixable) fluids. This research will lead to more sophisticated fluid science experiments and eventually may enable the development of important new materials in space.

DPM will fly on the Space Shuttle Columbia (STS–50) as part of the first U.S. Microgravity Laboratory (USML–1), a set of space-based experiments using the Shuttle's Spacelab facility. The scheduled 13-day mission — which would be the longest Space Shuttle mission in history — is currently set to launch in the summer of 1992.

Three investigators will conduct experiments using DPM: Dr. Robert Apfel from Yale University, Dr. Taylor Wang from Vanderbilt University and Dr. Michael Weinberg of the University of Arizona. Dr. Eugene Trinh, a Payload Specialist, and Dr. Bonnie Dunbar, a Mission Specialist, will operate the module in orbit.

The experiments are funded by the National Aeronautics and Space Administration (NASA) Office of Space Science and Applications, Microgravity Science and Applications Division. The Jet Propulsion Laboratory (JPL), an operating division of the California Institute of Technology, has developed DPM for NASA. Loral Electro-Optical Systems, Inc., constructed the module under contract to JPL.



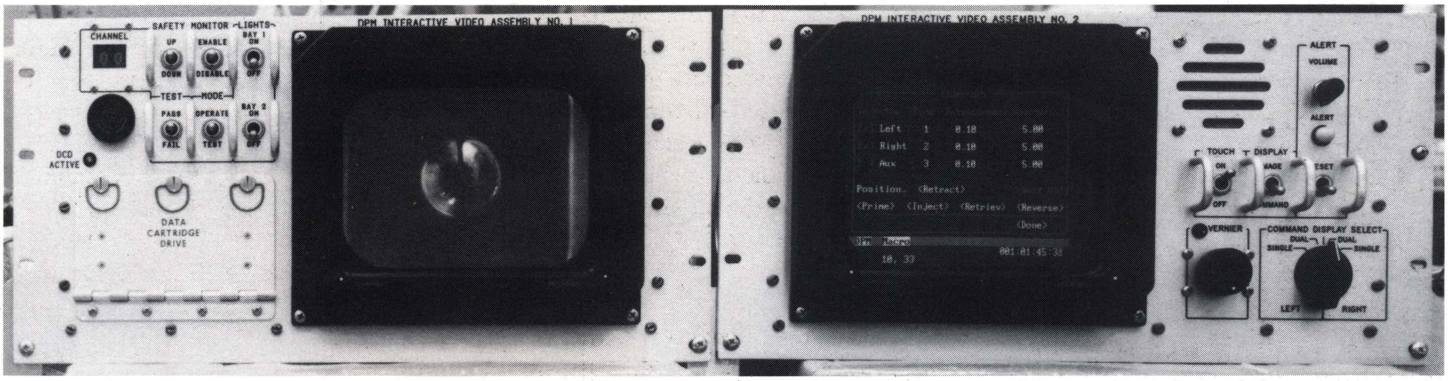
DPM, HOUSED WITHIN THE SHUTTLE'S SPACELAB, CONSISTS OF SEVERAL MAJOR ELEMENTS.

Science Overview

Before space travel, the dynamics of liquids not surrounded by containers were difficult to study. Aboard the orbiting Space Shuttle, DPM will permit scientists to investigate the macroscopic and microscopic properties and behavior of liquids in an environment of very little gravity (microgravity) while the drops float free of physical containment. A drop made up of one or more liquids, or a drop with a bubble, can be created. Then the energy of sound waves is applied to manipulate these drops in several different ways: While the drops are held steady in one position, they can be rotated, made to vibrate, split into smaller drops and recombined.

The sound waves — generated by four small loudspeakers and reflected off the walls of the module's acoustic chamber — interact in such a way that a quiet zone surrounded by acoustic force fields is formed. Then, by varying the relative frequencies emitted by the speakers, sound wave interactions can be adjusted to produce forces on the drops that result in the fluid dynamics just described.

The fluid dynamics studies made possible by DPM will provide research data that may be applied to the development of fuel-containing pellets for nuclear fusion reactors; the design of time-release medicines and diagnostic tracers that act in the bloodstream, and the manufacturing of food, drugs, chemicals and plastics



THESE INTERACTIVE VIDEO ASSEMBLIES ALLOW MONITORING AND CONTROL OF DPM EXPERIMENTS IN PROGRESS.

that go through liquid stages in their production cycles. This space-based research could also lead to a better understanding of the behavior of free drops on Earth and their role in the planet's weather and climate.

Fluid Dynamics Experiments

One set of DPM experiments will study the behavior of free-floating drops as they vibrate under the influence of sound waves. DPM's sound waves will distort single drops; when the sound energy is decreased, the drops will vibrate several times per second. The amplitude of the drop vibrations and the rate at which vibrations decrease and vanish after excitation ceases will be measured. Surfactants, which are agents (like detergents) that reduce the surface tension of liquids, will be used in these studies.

A second study will investigate the dynamics of liquid drops as they coalesce while floating free in the acoustic chamber. As two drops are pushed together by sound waves, they become distorted like toy balloons. Eventually, their molecular "skins," or surfaces, will rupture and the two drops will almost instantaneously become one. Surfactants will be used in these experiments to change the toughness of the molecular skins in contact.

A third set of experiments will seek to pinpoint the frequencies and modes of vibration that occur with different fluids (from distilled water to silicone oil); a fourth investigation will study the dynamics of drops spinning under the influence of sound waves as their shapes change and as each splits into two drops.

In still other experiments, one type of liquid will be injected into another to form compound drops. The multiple surface phenomena of the compound drops — interfacial tension between the two liquids in a drop where they meet each other and between the exterior surface and the air of the acoustic chamber — will be studied. Liquid shells (drops with large air bubbles inside) will also be examined for their multiple surface effects.

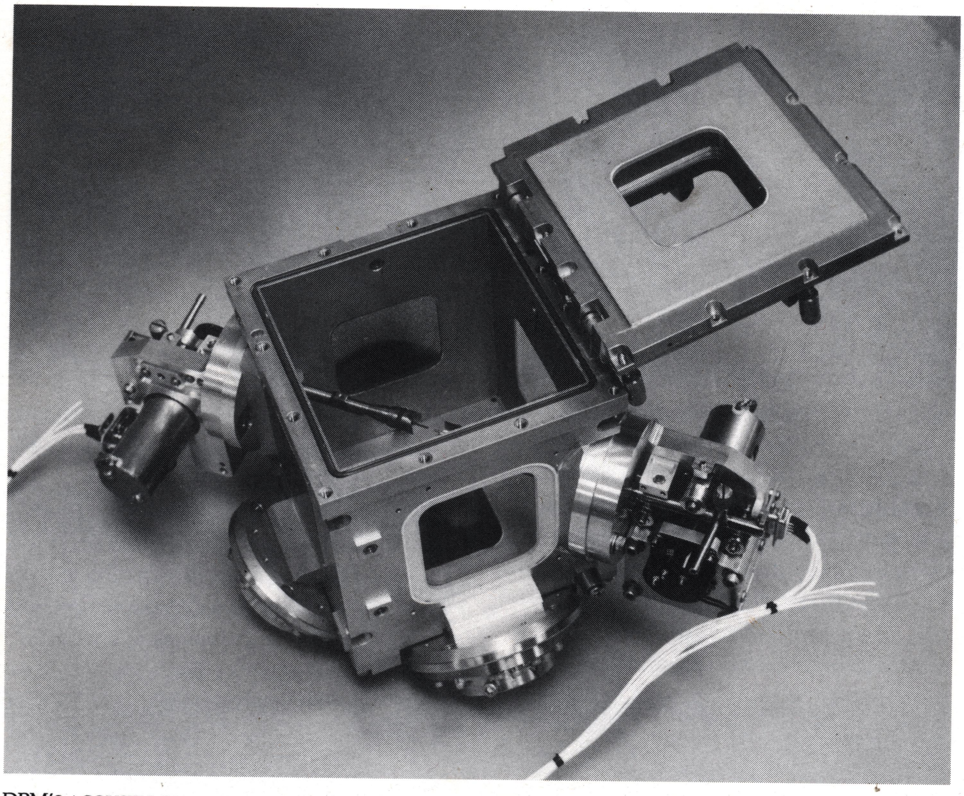
Finally, an experiment will attempt to verify a technique for measuring the interfacial tension between two immiscible fluids in a compound drop. DPM will form compound drops, then spin them. As they spin, their shapes will become distorted — the degree of distortion increasing with the rate of spin. The goal is to demonstrate that the degree of distortion and spin rate can be correlated to the interfacial tension.

Hardware Description

DPM is housed in one single and one double rack within the Shuttle's Spacelab and consists of six major elements: two power supplies, the computer control system, two interactive video assemblies and the mechanical assembly.

The power supplies draw low-grade electrical power from Spacelab and provide tightly controlled power to DPM. The computer control system handles such functions as safety monitoring, interface control and engineering data and operating software storage. For ease of use in microgravity, the interactive video assemblies feature menu-driven screens that are operated by touching them with a finger or stylus; the screens also serve as video monitors for inspection of experiments in progress.

The acoustic chamber, which is part of the mechanical assembly, allows liquid samples to be injected into and retrieved from the chamber and sound wave manipulation of the samples. The mechanical assembly includes a high-speed 16-millimeter camera and two high-resolution video cameras for recording the behavior of the drops. The video system permits time indexing of the images, which can be transmitted to Earth stations for immediate access by investigators.



DPM'S ACOUSTIC CHAMBER HAS LIQUID INJECTORS AND SPEAKERS FOR TRANSMITTING SOUND WAVES.

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Summary

The Jet Propulsion Laboratory (JPL) performs research, development and related activities for NASA. The Drop Physics Module Project is representative of JPL's role in performing basic scientific research in support of the nation's interests.

Flying on the Space Shuttle Columbia, DPM will conduct fluid dynamics experiments in a microgravity environment. These experiments, using sound waves to manipulate liquid drop samples, cannot be duplicated on Earth. The knowledge gained from DPM is expected to make significant contributions to future applications in the areas of medicine and nuclear fusion, as well as in food, drug, chemical and materials manufacturing.

DPM Mission Objectives

- Study the changes in surface properties of liquid drops. Larger drops and more spherical shapes than possible on Earth will be examined and compared to theory and other experimental results.

- Investigate the vibration and rotation of liquid drops.

- Verify a technique for measuring the interfacial tension between two immiscible liquids. Verification is accomplished by observing and measuring changes in the shape of the interface at various rotation rates.

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